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The Effect of Wages, Taxes, and Fixed Costs on Women's Labor Force Participation

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Number 238

May 1979

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Introduction

A structural model of labor force participation is useful for policy purposes because it permits explicit evaluation of the effect of policy paremeters such as income transfer levels and marginal tax rates. In the past decade much interest has focussed on the disincentive effects of the welfare program (AFDC) for female-headed households in the U.S. The very high marginal tax rate on earnings has been widely seen as an important cause of the very low labor force participation rates of welfare recipients. Calls for reform either by institution of a negative income tax (NIT) or family assistance plans have been designed to raise participation rates. Structural econometric models which make labor force participation a function of the level of wages, income transfer levels, and the tax system can attempt to answer questions such as the effect of lowering the marginal tax rates on labor force participation. The more traditional reduced form models which do not explicitly parametrize the tax system will be unable to answer such questions.[1] Thus in this paper we formulate and estimate a structural model so that the disincentive effects of tax and transfer systems can be evaluated. Furthermore, forecasts for alternative systems can be made using the estimated parameters.

The formulation of our model of labor force participation includes an element usually not considered explicitly in previous work: fixed costs to working. We find fixed costs to be empirically important. This finding implies that the reservation wage theory of labor force participation no longer necessarily holds true because an important non-convexity has been added to the problem. The reservation wage theory holds that for each person there exists a given reservation wage so that market wage offers above it induce labor force participation. But the presence of fixed costs and other non-convexities created by the tax system make this theory incomplete. The labor force participation model must be extended to consider wage and hour combinations rather than wages alone. A higher market wage may be required to induce a person who prefers to work part time into the labor market than a person who prefers to work full time. An important implication of this finding is that the complete budget set must be considered in assessing labor force participation. The essentially local reservation wage theory which considers what happens in the neighborhoold of zero hours is insufficient in a world of non-convexities created by taxes and fixed costs.

The model developed here is used to compare the effects on labor force participation of AFDC and a NIT on a sample of approximately 1000 black female-headed households in Gary, Indiana. The AFDC plan is characterized by an income transfer conditional on family size and a marginal tax rate on earnings of 67% up to a breakeven point. Four different NIT plans were used. Two levels of income guarantees were used, approximately 22% and 51% greater than the corresponding AFDC amount. These two transfer payments were combined with marginal tax rates of either 40% or 60%. Beyond the breakeven point, as with AFDC, the individual's earnings were taxed at the usual federal and state tax rates. A nonlinear and nonconvex budget set is created which must be taken into account in a model of labor force participation. A further complication arises because of the existence of a maximum payment level for AFDC recipients in Indiana. Even though the budget set is quite complicated, the model we estimate is conceptually quite straightforward. It is essentially a probit model which compares utility when working to utility when not working. The individual chooses the state which offers greater utility. The budget set creates a nonlinearity in the probit model, but since maximum likelihood techniques are required to estimate probit models in any case, the estimation problem is not difficult to solve.

The first section of the paper develops the theoretical model of labor force participation when taxes are accounted for. Nonconvexities may arise either from the tax system or through the presence of fixed costs to working. The reservation wage theory of labor force participation is replaced by a utility comparison theory. The utility comparison theory permits participation decisions to be modeled for any type of budget set even if it is nonlinear or nonconvex. In section 2 we specify the labor force participation model by starting with a linear labor supply function and solving for the associated indirect and direct utility functions. Two stochastic models are then specified which allow for a distribution of preferences for work in the population. In section 3 we derive the budget sets which arise from AFDC and the four NIT plans. The statistical model is specified and a nonlinear probit model is derived. Section 4 estimates the model for both truncated normal and a Weibull distribution of preferences. Also, the model is separately estimated for AFDC and NIT individuals. For all four models fixed costs are found to be an important element in labor force participation decisions. Fairly similar distributions of preferences are found forall four models. In the last section we evaluate the importance of high marginal tax rates as a disincentive to labor force participation by the female-headed households. The paper concludes with a discussion of possible future research.

1. Labor Force Participation with Taxes and Fixed Costs

The inclusion of taxes in a model of labor force participation has important effects on both theory and estimation. Taxes affect both net wages and "virtual" non-labor income. An important result is that the concept of reservation wage loses all of its operational significance.[1a] Under the usual assumption of an upward sloping supply curve at zero hours, it is certainly true that there exists a market wage high enough so that an individual would choose to work. However, there may well exist lower market wages which induce labor-force participation so long as a given number of hours of work come with the wage offer. Thus, in general a wage-hours package must be considered. The simple story of the reservation wage w^* with labor force participation by person j if $w \geq w^*$ no longer holds. Neither, in general, does a net reservation wage modification hold true. Combined with any net wage $w(1-t_i)$ are a set of hours h_j, min (w_i) and h_j, max (w_i) where the net wage holds. Both the net wage and the hours intervals over which it holds must be considered in assessing labor force participation. Furthermore, when fixed costs of working are considered, the reservation wage story breaks down even in a world without taxes. Both taxes and fixed costs add an essential nonconvexity to the problem which is important in models of labor force participation. The existence of this nonconvexity requires that the complete budget set be considered in assessing labor force participation decisions. The purely local considerations of the reservation wage model are no longer sufficient to determine whether an individual chooses to work.

To begin consider the familiar two-good diagram of hours supplied and expenditure on other goods where the slope of the budget set is the normalized wage $w = \tilde{w}/p$ and the intercept is $y = \tilde{y}/p$ where $\tilde{w}$ and $\tilde{y}$ are the market wage and non-labor income with the price p of the composite consumption good x as the numeraire.[1] No taxes or only a proportional tax are assumed to exist. In Figure 1.1 we draw the indifference curve through zero hours. Since we assume concave indifference curves, zero hours correspond to a utility maximum with market wage w. Now as the market wage rises we note there exists a wage w* where the budget line is tangent to the indifference curve at zero hours. The market wage w* then corresponds to the reservation wage because for any $w' \geq w^*$, desired hours of work H' which maximize utility will exceed zero hours. Thus, in this taxless world a model of labor force participation may be specified by a function which determines the reservation wage.

$$(1.1) \quad w^* = g(y,\ z,\ \varepsilon)$$

where z is a vector of individual characteristics and ε is a stochastic term. The theory of labor force participation then consists of comparing the market wage w with the reservation wage w* to decide if an individual decides to work.[2]

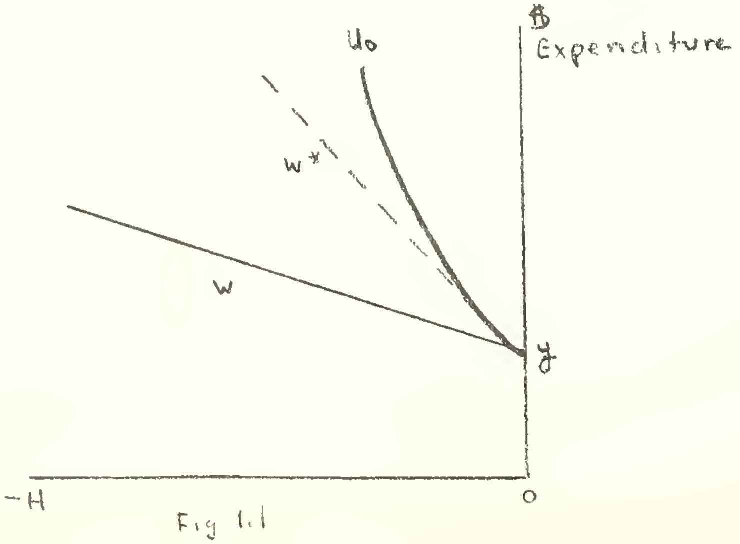


Fig 1.1

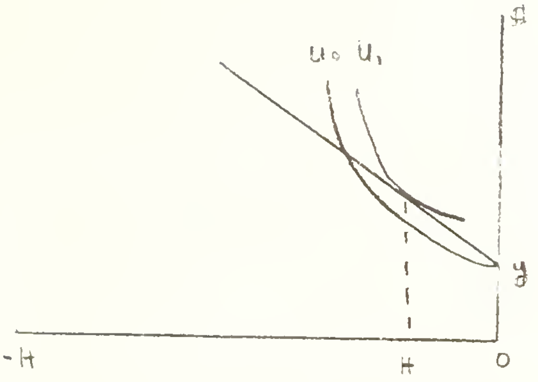


Fig 1.2

An alternative way to consider the problem of labor force participation is shown in Figure 1.2. As the market wage rises beyond w* it intersects the indifference curve at zero hours of work. Thus zero hours can no longer correspond to a utility maximum. A higher indifference curve u_1 will be tangent to the budget line. Preferred hours of work H > 0 will be determined by the tangency of u_1 and the budget line. From this perspective an equivalent theory of labor force participation is to find the utility maximum corresponding to the budget line (w, y). This maximum utility follows directly from use of the indirect utility function $u_1 = v(w, y)$. The maximum utility u_1 is compared to utility at zero hours of work u_0. If the difference in utility is positive, individuals participate. However, if the difference were negative, as would occur in Figure 1.1, then no work occurs. Thus, by comparing the maximum utility on the budget set to the utility at zero hours a model of labor force participation is determined. The importance of this model is that it can be extended to the non-linear budget set world created by taxes.

While the two theories of labor force participation are equivalent in the linear budget situation, only the utility comparison theory continues to hold when taxes enter the model. We first consider a non-convex two-segment budget set which corresponds to a negative income tax or AFDC in many states as in 2.1. The intercept y_1 corresponds to the

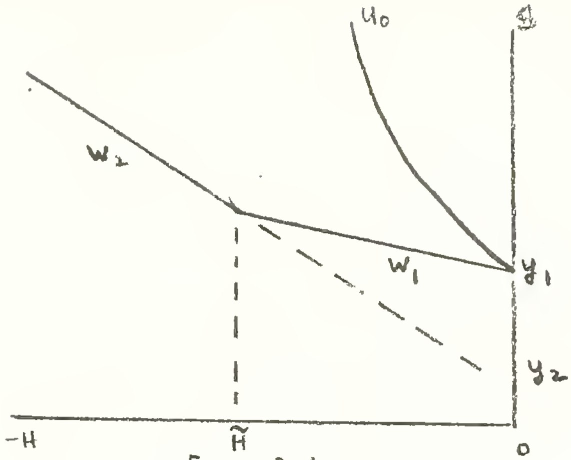


Fig 2,1

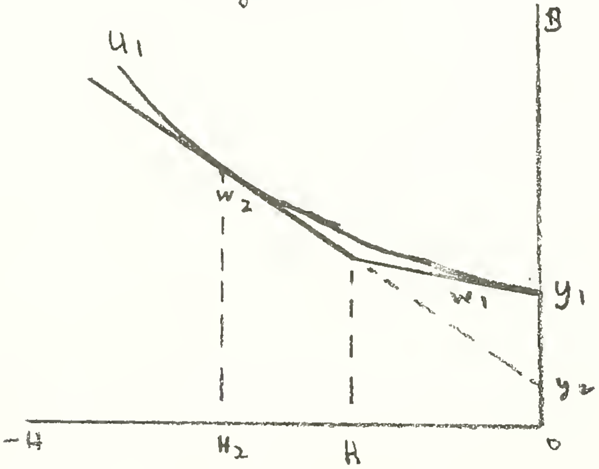


Fig 2,2

income guarantee which is a function of family size. The first net wage $w_1 = w(1-t_1)$ extends to the breakeven point $\tilde{H}$ where all government benefits have been taxed away. Beyond $\tilde{H}$, the individual faces a budget segment defined by virtual non-labor income y_2 and net wage $w_2 = w(1-t_2)$. The nonconvexity of the budget set occurs because t_1 is between .4 to .7 while the IRS tax rate plus social security causes t_2 to be around .25. What happens to the theory of the reservation wage in the presence of this nonconvexity? A consideration of Figure 2.1 demonstrates that as the market wage rises, the net wage on the first segment w_1 increases until tangency with the indifference curve u_0 is achieved for some w_1^*. Then as before for all net wages $w_1' \geq w_1^*$ the individual will choose to participate in the labor market. But the essentially local theory of the reservation wage can lead to error as Figure 2.2 demonstrates. Here as the market wage rises the initial tangency with the indifference curve through zero hours occurs on the second segment of the budget set at H_2 hours. Thus there may exist a lower market wage than the one corresponding to w_1^* which will cause labor force participation. This net wage w_2^* arises from the essential nonconvexity of the problem. But the individual may receive the net wage w_2 only if she works greater than the breakeven hours $\tilde{H}$. Thus net wage and hours combinations must be considered jointly. Consideration of the wage relationship alone is not sufficient.

By comparing maximum utility on each budget segment to utility at zero hours, the nonconvexity can be correctly treated. For the first budget segment compute the indirect utility $v_1(w_1, y_1)$. Preferred hours of work $h_1(w_1, y_1)$ may be greater than the breakeven point H so that the apparent utility maximum would lie below the second segment in the interior of the budget set. Likewise we calculate $v_2(w_2, y_2)$ and preferred hours $h_2(w_2, y_2)$. Then the maximum maximorum $v^*(w_1, w_2, y_1, y_2)$ will correspond to preferred hours $H^*(w_1, w_2, y_1, y_2)$ which will always lie on the boundary of the budget since for any level of hours an individual is better of on the boundary than in the interior. In order to establish whether the individual participates we compare maximum indirect utility $v^*(w_1,w_2,y_1,y_2)$ to utility at zero hours u_0. Depending on which is larger, labor force participation is determined. Note the essential global nature of the model which occurs in determination of $v^*(w_1, w_2, y_1, y_2)$. All budget segments need to be considered because of the non-convex budget set.

Another important case of the effect of taxes on labor force participation occurs from the effects of a progressive tax system. Again p 5A.

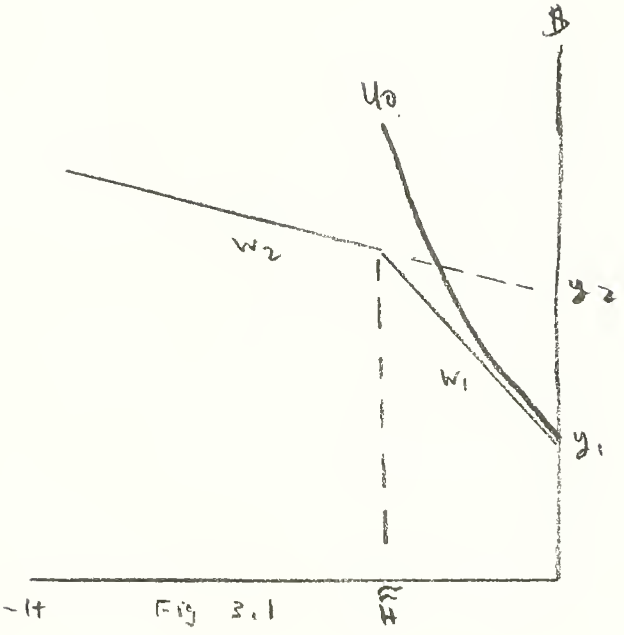


Fig 3.1

to simplify we consider only two budget segments as in Figure 3.1. Here the first budget segment with net wage w_1 holds until hours of work $\tilde{H}$ where the individual faces net wage w_2 and virtual non-labor income y_2. Since $w_1 > w_2$ because of the progressivity of the tax system, the reservation wage story can be applied. Therefore for this model which can be applied to wives' labor force participation, the absence of a non-convexity allows use of the local no-tax analysis of Figures 1.1 and 1.2.

Yet a potentially important element is missing from this model. There may well exist fixed costs of women's labor force participation due to transportation costs, alternative household arrangements, and other factors.[3] Hanoch [1976] in an interesting paper on women's labor force participation which did not consider taxes emphasized the importance of fixed costs by setting a lower bound H_0 to hours of work supplied. While H_0 should properly be a function of the net after tax wage, it can be observed in the data that an absence of very low hours of work exists for labor force participants. Of course, this finding may well be a function of the demand side of the labor market which lies outside the scope of our theory.

Denoting the fixed costs as FC, we see in Figure 4.1 that they lead to a downward shifting of the budget set except at zero hours where fixed costs are not incurred. The budget segment now consists of the point y_1 at zero hours where the indifference curve U_0 intersects the vertical axis. Then, as soon as labor supply becomes positive, we shift downward to virtual income y_1 - FC.[4] Net wages w_1 and w_2 are the same as before but virtual income income y_1 - FC also shifts by the amount of the fixed costs. As figure 4.2 demonstrates we are back once again to global considerations

Fig 4.1

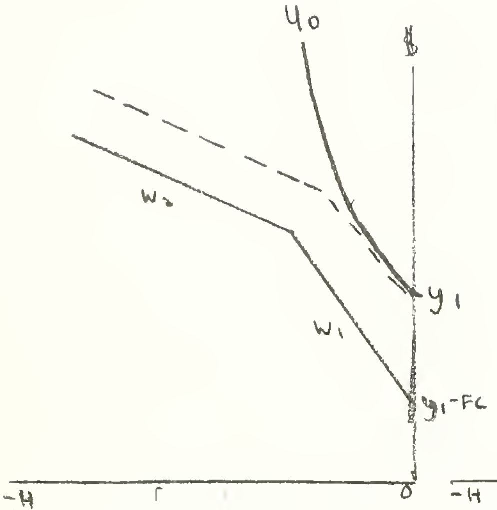


Fig 4.2

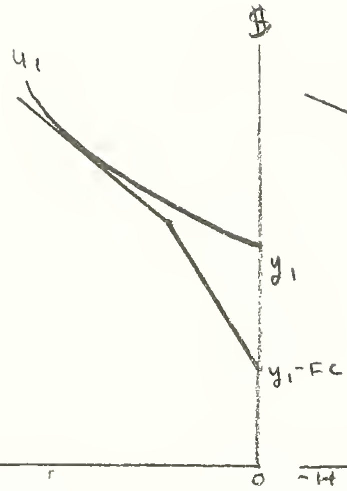
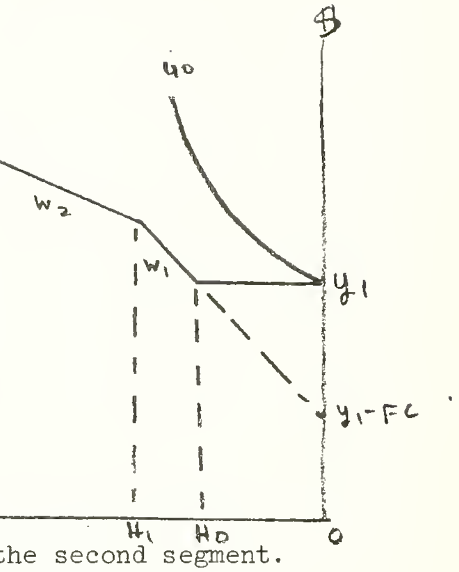


Fig 4.3



since initial labor force participation can occur on the second segment.

Whether this possibility has important empirical significance can only be decided by estimation. But as perhaps Figure 4.3 demonstrates best, the presence of fixed costs returns us to the non-convext budget set situation. A horizontal line extends from y_1 at zero hours of work to hours $H_0(w_1)$ which are the minimum hours an individual will choose to work. As the market wage rises even if the initial tangency with the indifference curve occurs on the first budget segment, the fixed costs are an important element of the model. Remember that H_0 is determined by the magnitude of the fixed costs and the net wage w_1. Once again corresponding to the first budget segment we calculate indirect utility $v_1(w_1, y_1\text{-FC})$ and hours of work $h_1(w_1, y_1\text{-FC})$ which may exceed H_1 or be less than H_0. Likewise, we compute indirect utility $v_2(w_2, y_2\text{-FC})$ and hours $h_2(w_2, y_2\text{-FC})$ which may be less than H_1. At most one of h_1 or h_2 can be feasible and it corresponds to the maximum maximorum of utility. If h_1 is feasible and is less than H_0 then zero hours of work is optimal. Otherwise $v^*(w_1, w_2, y_1\text{-FC}, y_2\text{-FC})$ is compared to utility at zero hours of work u_o. As before if v^* exceeds u_0 participation occurs. The other situation which may occur is that neither h_1 or h_2 is feasible. Then hours corresponding to the kink point H_1 are optimal. Knowledge of the direct utility function

function here is required so that a comparison of $u(H_1, x(w_1, y_1 - FC))$ can be made to utility at zero hours of work $u(0, y_1)$ where x is the amount of the composite consumption good. Thus, again a global model is required to determine labor force participation.

In the last case we consider fixed costs, even if small in magnitude, are likely to play an important role in labor force participation. This case corresponds to AFDC with a maximum payment or labor supply for social security recipients. The budget set shown in Figure 5.1 has three segments which create first a convex and then a non-convex section of the budget set. The initial segment with net wage w_1 extends to H_1 hours. It occurs in AFDC because of maximum payment limits in many states. The intercept y_1 equals the maximum welfare payment allowed plus any other non-labor income the family may have.[5] The effective tax rate on the first segment is usually only FICA payments of around .05 to .06. At H_1 hours of work the AFDC guarantee, which is a function of family size is reached. Above the guarantee level the high AFDC tax rate of between .5 and .67 is encountered. Then beyond the breakeven point H_2, the individual returns to the IRS tax schedule. It is important to realize that H_1 typically represents few hours per month. For instance under plausible assumptions in Indiana it can correspond to approximately thirty hours per month. Thus we might well expect someone in the labor market, even if she works part time, to be on the second budget segment rather than the first. The social security budget set for individuals over sixty-five years of age (or sixty-two for early retirement) is very similar to figure 5.1. In the case of social security y_1 corresponds to benefits while y_2-y_1 corresponds to the earnings maximum before a .5 tax rate on the second segment is encountered. At the current minimum wage, H_1 equals

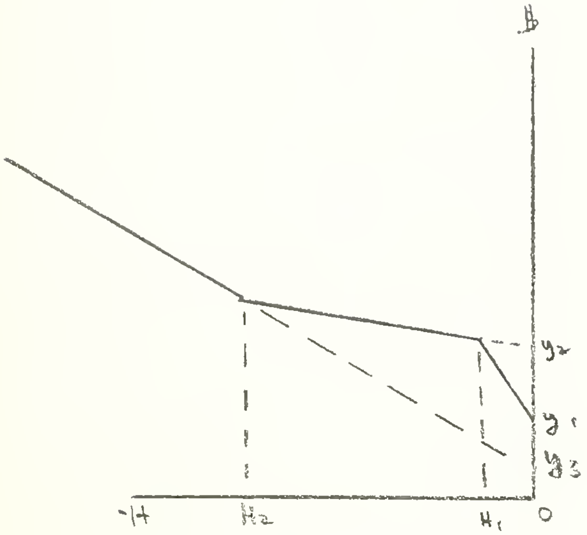


Fig 5.1

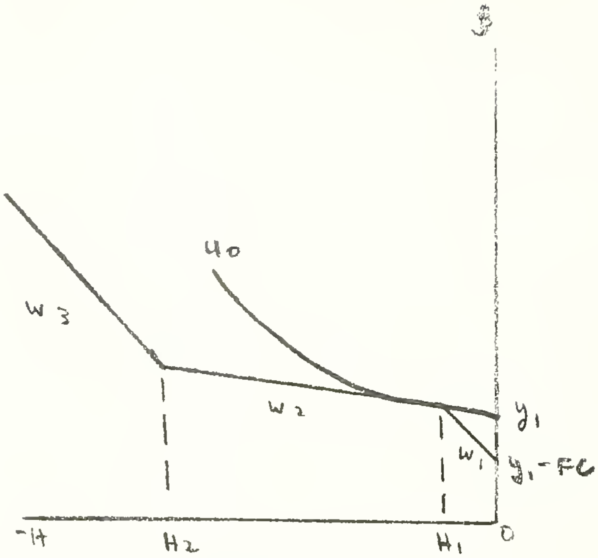


Fig 5.2

approximately fifty hours per month so that again people who choose to work are likely to locate on the second or third budget segment, or beyond for higher wage jobs.

The importance of the low size of H_1 becomes apparent when we add fixed costs to the model in Figure 5.2. It is now quite possible that no utility maximizing points will lie in the first budget segment since H_0 the minimum number of hours in Figure 4.3 can well exceed H_1 in Figure 5.2. Sufficient conditions for this event to take place are that w_1H_1 is less than the fixed costs. Even if w_1H_1 exceeds fixed costs, depending on the curvature of the indifference curve u_0 which goes through zero hours, labor force participation may well depend on an initial tangency with the second budget segment as the market wage rises. In fact, since $w_3 > w_2$ the initial tangency may occur on the third budget segment so that both sources of nonconvexity must be considered in a theory of labor force participation. To determine participation the greater of $v_3(w_3, y_3\text{-FC})$ and $v_2(w_2, y_2\text{-FC})$ is compared to the feasible point of either $v_2(w_2, y_2\text{-FC})$ or $v_1(w_1, y_1\text{-FC})$. The maximum maximorum $v^*(w_1, w_2, w_3, y_1\text{-FC}, y_2\text{-FC}, y_3\text{-FC})$ is compared to utility at zero hours $u(0, y_1)$. Depending on which is greater, labor force participation is determined. Thus again global considerations are required in analyzing the labor force participation decision and local reservation wage models which consider only w_1 are especially sensitive to the presence of fixed costs since H_1 usually corresponds to fewer hours than even a part-time job affords.

This section has developed a model of labor force participation which emphasizes the global requirements of considering the budget set because of the presence of non-convexities. These non-convexities may arise from two sources. First, they may arise from government transfer programs such as an NIT or AFDC where earnings up to the breakeven point are taxed at a high marginal rate. The second source of non-convexity arise because of the possible presence of fixed costs in labor supply. Then a given minimum number of hours of work for participation are determined as a function of the magnitude of the fixed costs and of the net wage. Even in the case of a wholly convex budget set (including the no tax case) the considerations which arise with fixed costs make the local reservation wage story inapplicable. To have a complete model of labor force participation, the entire budget set along with all the net wage rates and all the virtual incomes must enter the model. While this development inevitably complicates a model of labor force participation, the next section developes an econometric model which is only slightly more complicated than the familar probit model which has often been used in this area.

2. Model Specification

In this section we initially develop a model of labor force participation for a given individual. The model is then extended to a population of individuals by making appropriate stochastic assumptions. The basic approach is similar to Burtless-Hausman [1978] who considered the effects of taxation on the labor supply of prime age males. But the situation here differs in two respects. First, we are not primarily interested in hours of work but rather in labor force participation. Next, Burtless-Hausman did not treat the zero hours situation since it was not considered a serious problem in a study of prime age males. But in the current study of labor force behavior of female headed households, zero hours are the essence of the problem since approximately twenty-five percent of the sample works. Thus we concentrate on the zero hours situation which requires use of a direct utility function as well as an indirect utility function of the type used by Burtless-Hausman. Development of the direct and indirect utility functions are the initial goal of this section.

As in the Burtless-Hausman paper two approaches to the problem are considered. The first approach is to assume a particular parametric form of the underlying direct or indirect utility function. Since both dual forms of the preference map are required, Cobb-Douglas, CES, and the linear expenditure system might at first glance seem to be appropriate candidates.[1] Unfortunately, the strong elasticity assumptions of these utility functions make them inappropriate for models of labor supply. An alternative approach might be to begin with a flexible functional form such as either the direct translog utility function or the indirect translog utility function which are second-order approximations to an arbitrary utility function. The problem which arises with this approach is that say starting with the indirect translog utility function the corresponding direct utility function follows from solution of a constrained minimization problem. Unfortunately, the corresponding direct utility function does not usually exist in closed form.[2] It is, of course, incorrect to think that the parameters of the two translog systems when estimated from observations on consumer demand bear any simple relationship to each other. They are essentially two different approximations to families of indifference curves, one family of which is in quantity space and the other family of indifference curves is in price space. Furthermore, given the large number of unknown paramters in the flexible function forms, it becomes difficult to allow for a distribution of preferences which is an important part of our model.

Thus, we adopt the second approach which is similar to Burtless-Hausman. We begin with a linear specification of labor supply which can be considered as a first order approximation to an arbitrary labor supply curve. This labor supply curve has often been used both in studies of women's labor supply and in reservation wage studies of women's labor force participation. The linear specification has the form

$$(2.1) \qquad h = \alpha w + \delta y + Z\gamma + \varepsilon \qquad\qquad h \geq 0$$

where w is the net wage, y is virtual non-labor income, Z is a vector of socio-economic characteristics and ε is a stochastic term. Since we will be dealing with preferred hours h^* of work we delete ε and set $s = Z\gamma$ to ease notation so that $h^* = \alpha w + \delta y + s$. We now proceed to derive the underlying indirect and direct utility functions using Roy's identity and duality theory.

Before proceeding to derive these functions, we should attempt to clear up a possible confusion. As Burtless-Hausman and section 1 both tried to emphasize, a correct treatment of labor supply or labor force participation in the presence of non-linear budget sets requires specification of a parametric form of an underlying utility function in either direct or indirect form. But corresponding to any well-behaved labor supply equation of the form of equation (2.1) is an underlying indirect and direct utility specification. This statement is the essence of the classical integrability problem in economics.[3] The only requirements that a system of demand equations must satisfy to be derivable from a utility specification are the Slutsky conditions and a weak Lipschitz condition, which can usually be ignored. Thus, the requirement of using the indirect and direct utility functions in the case of nonlinear budget constraints raises only computational difficulties. Closed form solutions of the indirect and direct utility functions ease computational problems but are not even necessary given modern computers for models of the type we consider. Thus, there is nothing "wrong" or unduly restrictive in choosing a utility specification. Choice of a labor supply equation is equivalent to choice of a utility specification. To the extent the labor supply equation is a robust approximation to the data, so will the utility function be a good approximation given their one-to-one correspondence between demand functions and underlying utility specifications.[3a]

The general indirect utility function is determined by the solution to the constrained utility maximization problem in the linear budget case or along a given linear budget segment of a non-linear budget set

$$(2.2) \quad v(p, y) = \max_x \, [u(x): p \cdot x \leq y]$$

where x is an N vector of consumption goods, one of which may be labor supply, and p is a vector of (net) prices. The relationship between the demand equations and the indirect utility function follows from Roy's identity.

$$(2.3) \quad x_i = \frac{\partial v(p,y)}{\partial p_i} \Bigg/ \frac{\partial v(p,y)}{\partial y} \qquad i = 1, \ldots, N$$

Thus, as Burtless-Hausman did we will begin with a specification of labor supply from equation (2.1) and solve the system of first-order partial differential equations corresponding to the indirect utility function in Roy's identity.

Now it is extremely difficult to solve the N good case

for the two good model used here closed form solutions are often possible. Using a negative sign for labor supply to retain the usual concavity conventions

$$(2.4) \quad h^* = + \frac{\partial v(w,y)}{\partial w} \Bigg/ \frac{\partial v(w,y)}{\partial y} = \alpha w + \delta y + s.$$

The solution method of separation of variables used by Burtless-Hausman cannot be applied in this case so we instead use the method of characteristic curves of linear partial differential equations.[4] Along a characteristic curve (indifference curve) we can consider y as a function of w and write the ordinary differential equation

$$(2.5) \quad y' + \delta y + (\alpha w + s) = 0.$$

Solving this ordinary differential equation and using the constant of integration c as our cardinal utility index we derive the indirect utility function.

$$(2.6) \quad v(w, y) = c = e^{\delta w} \left(y + \frac{\alpha}{\delta} w - \frac{\alpha}{\delta^2} + \frac{s}{\delta}\right)$$

The monotonicity requirement of the indirect utility function in income will be satisfied for all parameter values while monotonicity in the wage will require the ratio $\frac{\alpha}{\delta}$ to be negative which is to be expected with $\alpha \geq 0$ and $\delta < 0$ for low income workers. Concavity conditions from the Slutsky term $0 > s_{ww} = \delta^2 e^{-\delta w} v(w,y)$ will be satisfied again for $\alpha \leq 0$ and $\delta > 0$ so long as s is positive and $h^* \geq 0$ as would be expected.

Derivation of the corresponding direct utility function follows from the solution of the dual constrained minimization problem of equation (2.2)

$$(2.7) \quad u(h,x) = \min_{w,y} \; [v(w,y)\colon x - wh \leq y]$$

since the price of the composite good has been set at unity. To simplify notation set $b = \frac{\alpha}{\delta}$ and $\tilde{s} = \frac{s}{\delta} - \frac{\alpha}{\delta^2}$ and then substituting out the constraint leaves us with the unconstrained problem

$$(2.8) \quad u(h,x) = \min_{w} \; [e^{\delta w} (-wh + x + bw + \tilde{s}].$$

After some straightforward algebraic simplification we derive the direct utility function

$$(2.9) \quad u(h,x) = e^{-\left[1 + \delta(x+\tilde{s})/(b-h)\right]} \left(\frac{h-b}{\delta} \right).$$

It is easily checked that this quite simple form of the utility function is correct by solving the constrained maximization problem for the labor supply function and verifying that it gives the labor supply equation (2.1). Since in section 1 it was seen that the primary requirement of the direct utility function is to evaluate u_0 for zero hours of work we solve

$$(2.10)\quad u_0 = u(0,x) = e^{-\left(\frac{\delta^2 y_1 + \delta s}{\alpha}\right)\left(\frac{-\alpha}{\delta^2}\right)}$$

since $x = y_1$, nonlabor income, at zero hours of work.[4a] Thus, given the indirect utility function of equation (2.6) and the direct utility function of equation (2.10) we can compare the maximum utility on a given budget segment as a function of (w_i, y_i) to utility at zero hours, $u_0 = u(0, x)$ to determine whether the person chooses to participate in the labor market.

We have derived the indirect and direct utility functions for an individual whose labor supply equation corresponds to (2.1). In extending the model from an individual to the population we need to think carefully about the sources of stochastic variation. Based on the Burtless-Hausman results and other work in the field it seems that the most important component of stochastic variation is to permit a distribution of tastes. To do so we initially specify a distribution of δ parameters for person j.

$$(2.11)\quad \delta_j = \mu_\delta + v_j$$

where v is distributed iid with zero mean and variance σ_v^2. Under this specification from equation (2.1)

$$(2.12)\qquad h_j^* = \alpha w + \mu_\delta y + Z_j \gamma + v_j y$$

so ε has mean zero and variance $\sigma_v^2 y^2$. A more general specification which is also considered is to allow μ_δ to be a function of the socioeconomic variables Z so $\mu_{\delta_j} = Z_j r$. However since Z also appears in the intercept of the equation it is difficult to sort out the separate contributions of the socioeconomic variables.

Both in the Burtless-Hausman research and in the research reported here variation in δ appears to be considerably more important than similar variation in α, each considered separately. It becomes difficult to consider variation in them jointly in a model of labor force participation because of the complex statistical model which results.[5] Thus only allowing δ to vary results in a model which we will call the one stochastic factor model. The model determines preferred hours of work and labor force participation for a given individual as a function of his net wages, virtual incomes, socioeconomic characteristics, and unobservable parametric δ_j as well as the common parameters of the model.

A more general stochastic specification which we will call the two stochastic factor model arises from allowing for the usual stochastic ε, say ε_{2j}, in equation (2.1). In the typical hours supply model, this stochastic term arises due to the divergence of preferred and actual hours. However, in a model of labor force participation this argument for inclusion of ε_{2j} does not seem so compelling. Presumably if preferred hours of work $h_j^* = 0$ because u_0 exceeds maximum utility along any budget segment an unexpected divergence between desired hours and actual hours will not occur since the individual will stay out of the labor market. It could be argued that if $h_j^* > 0$ actual hours could equal zero due to stochastic reasons. While this reasoning is somewhat convincing over a short time period such as a month or a quarter, it becomes unconvincing over a longer time period. Since our estimation will consider labor force participation over a two-year period, if $h_j^* > 0$ it is highly implausible that stochastic reasons kept $h_j = 0$ for the two years. However, ε_{2j} can arise also because of an inexact model of h_j^*, especially with regard to the socioeconomic specification $s_j = Z_j\gamma$. Allowing for a stochastic term here yields $s_j = Z_j\gamma + \nu_j$ where ν_j is assumed iid with mean zero and variance σ_ν^2. Then the preferred hours supply equation has the form

$$(2.13)\ h_j^* = \alpha w + \mu_\delta y + Z_j \gamma + v_j y + \nu_j$$

so the ε from equation (2.1) has mean zero and variance $\sigma_v^2 y^2 + \sigma_\nu^2$. In this two stochastic **factor** model then both δ and s vary across individual for both nonstochastic reasons $Z_j\gamma$, and stochastic reasons, $v_j y + \nu_j$. Only α is not permitted to vary across individuals. The two factor model leads to a bivariate probit model rather a univariate probit model, but the additional complication can be treated directly as will be shown in section 3.

In this section we began with an initial linear labor supply equation and derived the indirect utility function using Roy's identity and the corresponding direct utility function by solving the dual minimization problem. As we discussed in section 1 knowledge of both the direct and indirect utility functions is required to consider fully the labor force participation decision when non-convex budget set exist. Then we attempted to give careful considerations to the stochastic specification of the model. Allowing for a distribution of preferences seems essential in a well-specified model of labor supply. This observation arises from the fact that the large divergences in hours worked or labor force participation decisions for approximately observationally equivalent individuals seems difficult to account for using only the traditional additive disturbance term. The additive disturbance term represents the divergence between preferred hours and actual hours of labor supply, but it seems to persist for a given individual over time. It seems appropriate to model this persistence as differences in underlying tastes. In fact, Burtless-Hausman in their study of prime-age males found that the taste variation accounted for approximately eight times as much variation as did the additional stochastic disturbance. However, in our two stochastic factor model we allow for both sources of variation so that the current paper can produce more evidence on the questions of the appropriate stochastic specification.

3. Budget Sets, Fixed Costs, and the Likelihood Function

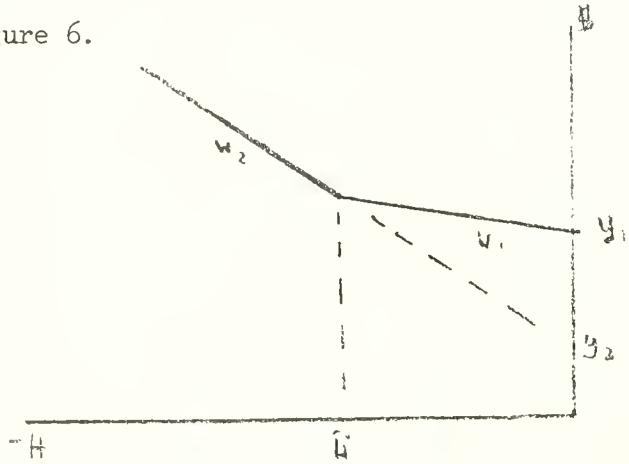
We now consider the specific budget sets faced by the black female headed households in the Gary negative income tax experiment. All such women either were classified as experimentals so that their budget set has the nonconvex form of Figure 2.1 or were classified as controls so that they qualified for AFDC and their budget set had the form of Figure 5.1. For some control individuals the maximum payment restriction of AFDC did not impose a binding constraint so that their budget sets have the form of Figure 2.1 although with a different guarantee level and tax rate from the NIT individuals. At the same time as we consider the budget sets, we will indicate how we include the fixed costs to working in the model. Although we might well expect fixed costs to be important, we do not want to impose them on the model. Rather, the fixed costs enter the model in a way so that their importance can be determined on empirical grounds. For the budget sets including the possibility of fixed costs, we then determine the probability of labor force participation. The one stochastic factor model is considered initially; subsequently, we derive the probability for the two stochastic factor model.

Each experimental individual in the Gary NIT experiment faced one of four experimental plans. Since the NIT treatment can be characterized by the level of the guarantee and the marginal tax rate up to the breakeven point, we call the treatments low guarantee and high guarantee and low tax rate and high tax rate, respectively . The income guarantee is based on the poverty limit which is a function of family size and local price levels. The poverty limit changed across the different years of the experiment but for the middle year, 1972, it was \$2808 for a family of two, \$4275 for a family of four, and \$5673 for a family of six, to give some idea of the actual levels. The low guarantee corresponded to .75 of the poverty limit while the high guarantee equalled the poverty limit. The low tax rate was set at .4 of labor earnings up to the breakeven point while the high tax rate was .6 of labor earnings. Beyond the breakeven point the individual returns to the IRS schedule. We parametrize the IRS schedule as two segments. Assuming that individuals take the earned income credit and standard deductions the first IRS budget segment extends to H_1 hours and has a tax rate of .0785 which includes FICA and Indiana state income tax. The IRS kink point of the budget set is

$$(3.1)\ H_1 = (\$1100 + \$625m - y_1)/w$$

where m are the number of family members and y_1 is non-labor income.[1] Beyond the H_1 kink point the tax rate rises to .2585 which takes account of the next IRS tax bracket. In our sample the NIT breakeven point $\tilde{H}$ exceeds H_1 for all individuals so that the experimentals face a two segment budget set as shown in Figure 6.

Fig 6



Non-labor income y_1 corresponds to the income guarantee with $w_1 = (1-t_1)$ and t_1 takes the value .4 or .6 depending on the experimental treatment plan. "Virtual" non-labor income y_2 is the extension of the second budget segment to the zero hours axis. It is important to note that breakeven hours $\tilde{H}$ are high enough so that for many individuals they would never be reached, especially if their gross wage was under \$2.00 per hour. Thus, most individuals will be "on the experiment" even if working. But since the non-experimental alternative is AFDC no special normative significance should be attached to this finding. At reasonable income guarantees, breakeven hours are bound to be high given typical wage rates unless tax rates are exorbitant which would add to the work disincentive for these individuals.

Fixed costs enter the model as in Section 2 by shifting down the effective budget set for an individual. Of course, the position of breakeven hours remains the same since the costs are not tax deductible. Since we might expect fixed costs to depend on socioeconomic factors as well as a constant we set $FC = Z_2\gamma_2$ so that preferred hours h^* have the form below breakeven

$$(3.2)\quad h^* = \alpha w_1 + \delta y_1 - \delta Z_2\gamma_2 + Z_1\gamma_1 \qquad \text{for } h^* > 0$$

where $s = Z_1\gamma_1$ to distinguish it from fixed costs. The vectors Z_1 and Z_2 will have elements in common although in general they will not be identical. However γ_1 and γ_2 are identified in all cases since fixed costs to working are not incurred at zero hours.

We now proceed to calculate the probability of labor force participation given the budget set in Figure 6 modified to take account of fixed costs as in Figure 7.

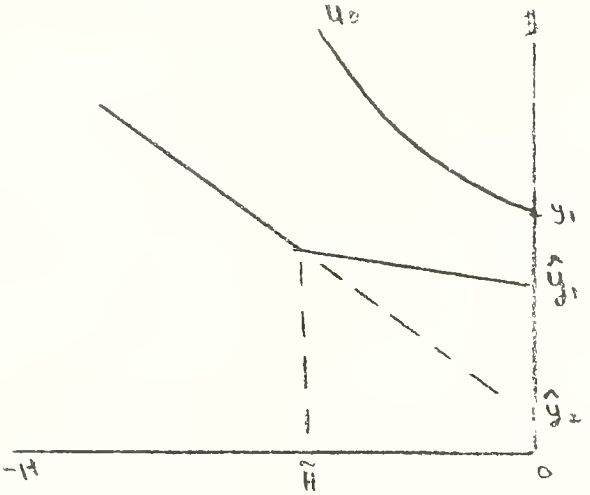


Fig 7.

If an individual is not working she receives the guarantee y_1 dollars. However, if she is working and on the first budget segment her non-labor income is $\hat{y}_1 = y_1 - FC$ and similarly on the second segment $y_2 = \hat{y}_2 - FC$. Of course, fixed costs could be estimated to be zero so that the budget set in Figure 7 could revert to that in Figure 6. Now we proceed to consider the question when will a given individual decide to work. Depending on her unobservable value of δ the utility of not working is given by u_0 calculated from equation (2.10). By assumption δ lies in the interval $(-\infty, 0)$. For large negative values of δ the indifference curve u_0 will rise steeply from the zero hours point in Figure 7. An alternative way to see this is in equation (2.1), h^* will be negative and would remain so if w_2 and y_2 replaced w_1 and y_1. Then as δ starts to rise towards zero the u_0 indifference curve in Figure 7 rotates counterclockwise, and for some δ^* becomes tangent to either the first or second budget segment.[3] Now we want the minimum δ^* which causes tangency and at the same time we do not want to choose a δ^* which causes u_0 to intersect one of the segments of the budget set. But we can assure ourselves of satisfying these criteria by making use of the indirect utility function of equation (2.6)

$$(3.3) \quad v(w_i, y_i) = e^{\delta w_i} \left(\hat{y}_i + \frac{\alpha}{\delta} w_i - \frac{\alpha}{\delta^2} + \frac{1}{\delta} Z_1 \gamma_1\right)$$

Then given an initial tangency of u_0 and one of the budget segments, the given indifference curve $u_{\delta*}$ cannot intersect the other budget segment due to the concavity of the indifference curve.[4]

To solve for $\delta*$ we thus equate utility of u_0 with indirect utility on a given budget segment. Define the function $g_i(\delta)$ as the difference in utilities of not working and of working on a budget segment (w_i, y_i) as

$$(3.4)\quad g_i(\delta) = u_0 - v_i(w_i, y_i) = e^{-(\frac{\delta^2 y_1 + \delta s}{\alpha})} (-\frac{\alpha}{\delta^2}) - e^{\delta w_i}$$

$$(\hat{y}_i + \frac{\alpha}{\delta} w_i - \frac{\alpha}{\delta^2} + \frac{1}{\delta} Z_1 \gamma_1)$$

We look for δ_i^* which sets equation (3.4) to zero. For a given budget segment (w_i, y_i) no δ_i^* need exist, although one or more $\delta*$ will exist when all the budget segments are considered. Although no explicit formula for δ_i^* exists the root of equation (3.4) can be found quickly on a computer since $g_i(\delta)$ is monotonic for feasible hours on a budget segment. The minimum $\delta*$ is thus determined. Individuals who have $\delta \leq \delta*$ will chose not to work, while if $\delta > \delta*$ individuals will choose to work. Since δ is unobservable we posit a probability distribution for it in the population as we did in Section 2. Denote the density function of δ as $f(\delta)$, then the probability that person j chooses not to work is

$$(3.5)\quad \pi_j = \mathrm{pr}(h_j^* = 0) = \int_{-\infty}^{\delta_j^*} f(\delta)\, d\delta.$$

For $f(\delta)$ normal we have a straightforward probit model with the slight complication that δ_j^* is an implicit function of the unknown parameters rather than an explicit function as usual. Since we use the restriction that $\delta \leq 0$ we choose $f(\delta)$ as truncated normal but no additional complications arise beyond an extra term in the likelihood function which will be derived in the next section of the paper. Then the probability of working is the complement

$$(3.6) \qquad 1-\pi_j = \int_{\delta_j^*}^{0} f(\delta)\, d\delta \qquad .$$

where the upper bound of the integral arises from our restriction on $\delta \leq 0$. However, it is interesting to note that we are not limited to choosing $f(\delta)$ to be normal in this one stochastic factor model. Since we only need to evaluate the cumululative distribution at δ^* other possibilities such as the gamma distribution will be considered in the empirical work.[5] This flexibility of distributional choice is an attractive feature of the one stochastic factor model.

Having determined the probability of labor force participation of experimentals, we now consider control individuals who are on AFDC. With fixed costs included their budget segment is shown in Figure 8. Non-labor income for those individuals who do not work is y_1 which equals private non-labor income plus the AFDC maximum payment. Along the first budget segment $w_1 = w(1-t_1)$ with $t_1 = .0585$ since only FICA must be paid as tax.[6] Beyond H_1 hours the individual receives as non-labor income the AFDC guarantee which depends on family size plus her non-labor income minus the fixed costs of working so $\hat{y}_2 = y_0 + G - FC$. While the AFDC guarantee is a complicated function of numerous factors, the most important of which is family size, it is approximately .6 times the poverty limit. Since $w_2 = w(1-t_2)$ where the AFDC tax rate $t_2 = .67$, all experimental individuals face a preferred budget set to the control individuals since their guarantee is higher and tax rate is lower. H_2 hours in Figure 8 represents the breakeven point where the individual returns to the IRS tax schedule. Since the IRS

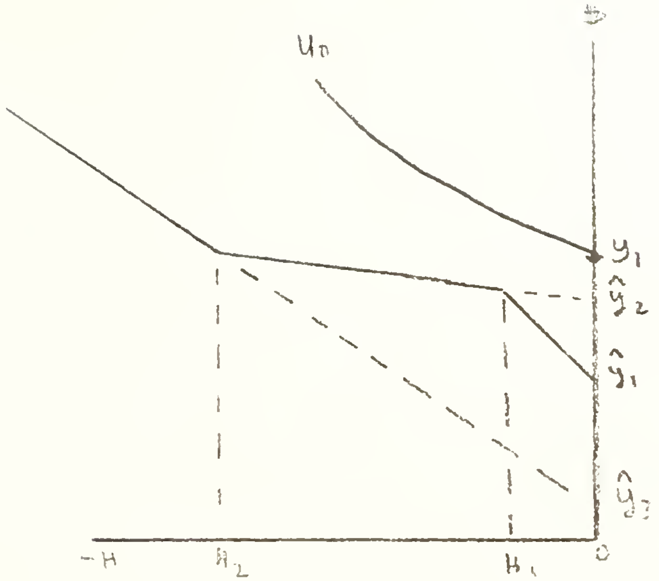


Fig. 8

kinkpoint of equation (3.1) is always less than H_2, $w_3 = w(1-t_3)$ with $t_3 = .2585$. It is interesting to note that at full-time hours many more individuals in AFDC will be beyond breakeven than under the NIT. Given the higher tax rate and lower guarantee, this is to be expected. The necessary wage required to be beyond breakeven depends on G, of course, but at approximately w = \$2.25 per hour, full time hours of work exceed H_2.

The determination of δ^* is similar to that for NIT individuals. As we emphasized in Section 1, due to presence of fixed costs, it is not true that the minimum δ which causes tangency will cause tangency on the first segment. In fact, for many individuals, it is much more likely that δ^* causes tangency on the second segment given the small size of H_1. Thus, for this case the reservation wage analysis would be incorrect, since it would lead to downward biases in estimation of the reservation market wage (and therefore upward bias in wage elasticity estimates). The calculation of δ^* follows from $g_i(\delta)$ of (3.4) where three budget segments are now considered rather than two segments. Then the probability of participation follows from either equation (3.5) or equation (3.6). Any number of budget segments can be treated in this way with almost no increase in complexity. Calculation of δ^* remains the same, and then a simple probit or other cumulative probability distribution needs to be evaluated.

We now derive the probability of working for the two stochastic factor model of equation (2.13). Since we have two additive sources of stochastic disturbances we become much more limited in our choice of the probability density for δ, $f(\delta)$.[7] We choose $f(\delta)$ to be truncated normal and ν in equation (2.13) to be normal distributed as $N(0,\sigma_\nu^2)$. Within the context of the two stochastic factor model we make one simplifying assumption. The assumption is that u_0 in equation (2.10) is calculated at the expected value of ν, namely zero. Otherwise equation (2.10) would lead to a log normal density as well as a normal density which would greatly complicate the analysis.[8] With this assumption δ^* is calculated in the same way as before through equation (3.4). Then beginning with δ^* we calculate the different limits of δ which correspond to different segments. Burtless-Hausman discuss this technique at length so we only outline the technique here. Suppose for the negative income tax individuals δ^* falls on the first segment. As δ rises individuals prefer more hours until for some δ their indifference curve is simultaneously tangent to both budget segments. Call this value of δ, $\bar{\delta}$. Then as δ continues to rise toward zero they will move along the second segment. But for all these values of δ greater than δ^* the individual may still not participate in the labor market due to ν_j. The probability that they will not participate is then

$$(3.7)\quad \pi_j = \int_{-\infty}^{\delta^*} f(\delta)\, d\delta + \int_{\delta^*}^{\bar{\delta}} \int_{-\infty}^{q_1} f(\delta)\, f(v_1)\, dv_1 d\delta + \int_{\bar{\delta}}^{0} \int_{-\infty}^{q_2} f(\delta) f(v_2) dv_2\, d\delta$$

where $v_i = \delta\hat{y}_i - \nu$ so that v_i is distributed normally as $N(\bar{\delta}\,\hat{y}_i, \sigma_\delta^2 y_i^2 + \sigma_\nu^2)$

and $q_i = -\alpha w_i - Z_1\gamma_1$. The probability densities in each of the last two integrals in equation (3.7) are both normal so that the joint density is bivariate normal which can be rapidly evaluated on a computer. Exactly similar techniques would hold true for the AFDC case. The increase in complexity of the model is not especially great. It remains an empirical matter to assess the gains from generalizing the model in this manner.

In this section we have developed the specific budget sets faced by the two groups of individuals in our data set. The NIT experimentals face a two-segment budget set which comes from the NIT experiment tax and guarantee parameters as well as the IRS tax schedule beyond the breakeven point. Calculation of δ^* divides people into labor force participants and non-participants as well as determining the minimum preferred hours of work for an individual. The minimum preferred hours for person j are

$$(3.8) \quad h_j^* = \alpha w_i + \delta_j^* \hat{y}_i + Z_1\gamma_1$$

where w_i and $\hat{y}_i$ are determined by the segment the initial tangency occurs on. In general $h_j^* > 0$ so that the reservation wage analysis does not hold true here. The probability of working in both the one stochastic factor and two stochastic factor models were developed. It is interesting to note both the simplicity and flexibility that the one stochastic factor model allows for. The probability calculations are extremely simple and a wide variety of probability distributions for δ can be used. However, allowing for two or more stochastic factors does reduce significantly the flexibility of the specification because of the increase in computational complexity.

4. Estimation

The model of labor force participation is estimated from a sample of 990 black females who were heads of household over the period 1971-1974. The data were collected from the Gary (IN) NIT experiment which took place from 1971 to 1974. One of the four experimental plans was faced by 595 women, while 395 women were on AFDC. Participation data were used from the middle two years of the experiment for each individual. We fit the one stochastic factor model to the joint sample and also to experimentals and AFDC recipients separately.[1] Also, two different distributions are used to model the distribution of tastes, $f(\delta)$. Both of these procedures are used to check on the robustness of the model. Time considerations did not permit estimation of the two stochastic factor model. We leave this estimation to future research.

Since only 27.7% of the females in the sample were labor-force participants, we used a missing data prodedure of Griliches-Hall-Hausman [1978] to form an estimated wage which is used in the estimation.[2] As applied here the model consists of one reduced form probit participation equation which excludes wages. The second equation is a wage equation. Market wages are observed for labor force participants but are unobserved for non-participants. An interesting question to be considered is whether sample selection bias is present in the sense of significantly higher market wages existing for labor force participants. Maximum likelihood is used to estimate the model with the results given in Table 1. Both log linear and linear models were estimated with nearly identical results. Only the estimates from the latter model are presented since they are used in the subsequent estimation for labor force participation. The estimates of the

Table 1: Wage Prediction Equation

	Variable	Wage Equation	Participation Equation
1.	Education	.1313 (.0275)	.1117 (.0302)
2.	Age	-.0035 (.0037)	-.0091 (.0052)
3.	Experience	.0022 (.0013)	.0253 (.0009)
4.	Training	.0185 (.0112)	.2764 (.0243)
5.	Jobs	.0034 (.0211)	.1424 (.0155)
6.	Family Size	--	.0266 (.0276)
7.	Children under Six	--	-.0103 (.0084)
8.	Constant	.6636 (.4630)	-.2.2771 (.4568)
	Rho	-.1489 (.1976)	
	Sample Obs.	990	
	Likelihood function	-446.72	

wage equation are pretty much as expected with education having a large effect, and age, experience, and training having a smaller effect. No sample selection is evident since the coefficient $\rho = -.1489$ is both small in magnitude and insignificantly different from zero. Thus, the least squares regressions yield very similar estimates and wage predictions. The results of the structural estimation of the participation equations, to which we now turn, are extremely similar with either set of wage predictions used. The mean wage forecast is \$1.96 per hour (in 1972 dollars). Almost all labor force participants are below the breakeven for the NIT, and the majority are below the breakeven for AFDC.

The reduced form participation estimates from Table 1 indicate that education and age along with family size and children under six may enter the structural equation for labor force participation through the preferred hours equation (2.12) and the equation including fixed costs (3.2). We thus specified Z_1,which enters the model directly to be composed on a constant, education, and age minus 45 years for those women over 45, and a dummy variable for the presence of children under six.[3] These variables are expected possibly to affect the labor-leisure trade-off. For the fixed cost vector Z_2 which enters the model indirectly through shifting down the budget set for non-zero hours in equation (3.2), we specify a constant, a dummy variable for children under six, and family size. While Z_1 and Z_2 can contain the same list of variables, it was thought that education is unlikely to affect fixed costs. Since all households had at least two family members, family size is unlikely to affect the labor-leisure tradeoff, but might reduce the fixed costs of working.

The first model we estimate is a non-linear probit model with a truncated normal distribution used to specify $f(\delta)$ in equation (3.5). Therefore,

$$(4.1) \qquad f(\delta) = \frac{1}{\sigma}\,\phi\left(\frac{\delta - \mu_\delta}{\sigma}\right) / \left[1 - \Phi(\mu_\delta / \sigma)\right]$$

where $\phi(\cdot)$ is the standard normal density, and $\Phi(\cdot)$ is the standard normal distribution. The denominator of equation (4.1) is the probability that δ from the corresponding untruncated distribution is less than zero. The parameter σ from equation (4.1) is not normalized at unity as in the linear probit model. Here all the parameters are identified because in solving for δ^* in equation (3.4) the scale of δ is determined by w_i and y_i which correspond to a given interval of hours, say (H_1, H_2) in Figure 8 for w_2 and y_2. A change in scale of δ^* would lead to preferred hours h^* which in general no longer correspond to the budget segment characterized by w_i and y_i so that equation (3.4) would no longer hold. Thus, the additional information contained in the non-linear budget set is sufficient to identify the scale of all parameters in the model.

Reordering the observations so that the first group corresponds to participants we use equations (3.5) and (3.6) to form the log likelihood function

$$(4.2) \qquad LF = \sum_{j=1}^{N_1} \log \Phi\left(\frac{\delta_j^* - \mu_\delta}{\sigma}\right) + \sum_{j=1}^{N_2} \log\left[1 - \Phi\left(\frac{\delta_j^* - \mu_\delta}{\sigma}\right)\right]$$

$$- (N_1 + N_2) \log \left[1 - \Phi(\mu_\delta/\sigma)\right].$$

Remember that δ_j^* is defined implicitly by the budget constraint which the individual faces and her Z_1 and Z_2 vectors in equation (3.4).

The estimates from the nonlinear probit model are in the first column of Table 2. The first parameters we consider are the coefficients of the truncated normal distribution. As Figure 9 indicates, we are in the extreme tail of the normal distribution.

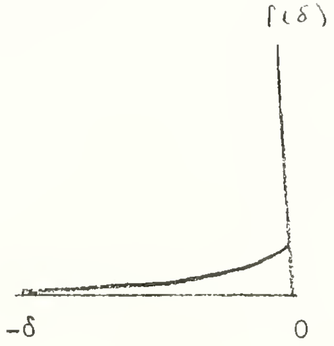


Figure 9

The mean of the $f(\delta)$ distribution is -.0497 with a median of -.0393 The coefficient for the wage equals .8612 which is positive as expected. The socioeconomic variables in Z_1 have the expected sign with the effect of age being measured more precisely than usual. The coefficients of the fixed costs variables are even more interesting. The coefficient of the constant is $95.61 per month which indicates substantial and significant fixed costs to working do exist. The presence of children under six increase fixed costs by 10% while the presence of other family members decreases it. The fixed costs thus have an important role in our model. At the mean wage of $1.96 per hour and mean fixed costs to working of $19.71 per week even if the high marginal tax rates of AFDC or the NIT did not exist and only FICA payments were required, 10.7 hours of work are required to reach the break-even point of covering fixed costs. When high marginal tax rates are present, say .67 for AFDC, then the required hours of work rises to 30.47 hours. Thus even beyond the usual income and substitution effects of income maintenance programs, the costs to working are a significant deterrent to labor force participation of female-headed households. They also lead to large nonconvexities as Figure 4.3 indicates is possible. Fixed costs thus seem a significant part of labor force participation models.

To consider further our parameter estimates, we now compute wage and non-labor income elasticities. Elasticities are not so meaningful when taxes are taken into account since changes may induce individuals to shift between budget segments as well as move along them. First for the case of the mean woman in terms of socioeconomic characteristics who is on the NIT with a .4 marginal tax rate and a guarantee of 1.0 times the poverty limit we find a small change in either the tax rate or guarantee has zero

Table 2: Estimates of Basic Participation Equation

Variables	Probit Model	Weibull Model
1. μ_δ (or c) nonlabor income	.5944 (.1199)	.8112 (.2452)
2. σ	.2031 (.1415)	.0546 (.0426)
3. α-wage	.8612 (.4560)	.6260 (.3355)
4. Constant	10.35 (3.521)	12.16 (3.138)
5. Education	.3938 (.2169)	.5214 (.3417)
6. Age-45 (for over 45)	-.1108 (.0542)	-.0235 (.0419)
7. Dummy for children under 6	-2.0259 (.5480)	-5.6490 (2.143)
8. Fixed costs: constant	95.61 (34.78)	108.7 (55.17)
9. Fixed costs: children under 6	9.531 (5.543)	7.165 (8.251)
10. Fixed costs: family size	-4.967 (1.945)	-1.921 (2.038)
Mean	-.0497	-.0611
Median	-.0393	-.0348
Standard Deviation	.0950	.0757
Sample Obs.	990	990
Log LF	-566.87	-558.86

elasticity: the woman is not working and will continue in that same state. For someone working thirty-seven hours per week full-time, the wage elasticity is +.0456. At the mean wage a change from the .4 marginal tax rate to the .6 marginal tax rate of the NIT would lead to a reduction in preferred hours to 36.67. Thus, the wage elasticity does not play a large role in the response to a NIT. The mean income elasticity at 37 hours is -.1053. Here shifting the income guarantee from 1.0 times the poverty limit to .75 times the poverty limit leads to an increase in preferred hours to 38.38 hours. Thus conditional on a woman working, neither the wage effect nor the income effect is especially large. The main effect of the NIT tax and guarantee parameters come in effecting an individual's labor force participation decision which we will further consider subsequently.

To test the robustness of our model we estimated the coefficients for another distribution for $f(\delta)$ beside the truncated normal. Since the gamma distribution proved to be computationally burdensome, we chose the Weibull distribution. The distribution function exists in closed form

$$(4.3)\quad F(\delta) = \exp\left[-(-\delta/\sigma)^{c}\right] \qquad \text{for} \quad \delta < 0$$

For $c \leq 1$ the density assumes an exponential shape with the mode at zero while for $c > 1$ a unimodal skew density function results. For c about 3.6 the shape is quite close to the normal. Maximum likelihood estimates for the Weibull model are given in the second column of Table 1. We again estimate an exponential-like density for $f(\delta)$, quite similar to the truncated normal found in Figure 9. The median of $f(\delta)$ is -.0348 which is about 12% less than the truncated normal while the mean= -.0611 is about 23% higher. Thus, the estimated Weibull distribution is more skew than the estimated truncated normal. The wage elasticity is also estimated to be about 1/3 lower than before. The socioeconomic coefficients are very much as before. Mean fixed costs are now estimated to be $24.13 per week when working. Thus reasonable agreement between the two models exists with fixed costs even somewhat more important than before. The elasticities are fairly similar, falling within sampling error of the two specifications.

Another test of the model was carried out by treating the experimental (NIT) individuals and control (AFDC) individuals separately. Results of these estimations using the probit model are included in Table 3. Most of the parameter estimates for the two samples are fairly close to the combined estimates in Table 2. The most important difference is the increase is fixed costs for controls. While they are within sampling error, nevertheless for controls the mean fixed costs rise to $23.79 per week. A likelihood ratio test for equality of coefficients for the two samples is 44.38. Thus we cannot reject the null hypothesis that the coefficients are different. The general form of the model holds up, but the coefficients may well differ due to the known limited duration of the NIT experiment.

In this section we have estimated the one stochastic factor model of women's labor force participation. Fixed costs to working seem to be a very important part of the model. For instance, AFDC participants will work almost nearly full time or greater if they work at all. Thus, while we do not find a large direct wage elasticity for women, we find a large indirect effect since high marginal tax rates keep nearly all but full-time workers out of the labor market. We also find strong evidence against the reservation wage approach to women's labor force participation. Again, for AFDC recipients the first segment of their budget segment up to H_1 hours in Figure 8 is irrelevant since working less than H_1 hours does not

Table 3: Probit Estimates of Experimentals and Controls Separately

Variables	Experimentals (NIT)	Controls (AFDC)
1. μ_δ -nonlabor income	.6103 (.1633)	.4568 (.2136)
2. σ	.2052 (.1827)	.1628 (.1384)
3. α -wage	.8582 (.5315)	.8278 (.6246)
4. Constant	10.31 (4.193)	11.7261 (6.235)
5. Education	.3910 (.3314)	.3292 (.4819)
6. Age - 45 (for over 45)	-.0918 (.0727)	-.0804 (.0761)
7. Dummy for children under six	-2.113 (.5672)	.6021 (.5571)
8. Fixed Costs:Constant	97.88 (46.11)	112.3 (65.44)
9. Fixed Costs: Children under Six	9.156 (8.056)	20.65 (30.05)
10. Fixed Costs: Family Size	-4.112 (1.236)	-6.262 (3.817)
Sample Obs.	595	395
Log LF	-325.55	-219.13
Mean	-.0619	-.0412
Median	-.0402	-.0349
Standard Deviation	.0422	.0775

equal the fixed costs of working. We attempted to test the participation model both by fitting another distribution besides the normal and by separating the sample into experimentals and controls. Fairly similar results are found in all four cases, although statistical tests reject the hypothesis of identical coefficients. We thus seem to have a consistent story from the model, but we may need to expand it to contain other factors. The two stochastic factor model comes next on the list to try.

5. Disincentive Effects and Conclusion

It was claimed in the introduction to this paper that one of the primary reasons to estimate a structural model of labor force participation is that disincentive effects of the tax and transfer parameters can be evaluated explicitly. The estimation results indicate that as expected a higher marginal tax rate lowers the probability of participation. Likewise, a higher transfer payment has the same effect. Here, we take the estimates from the probit model of Table 2 to evaluate the magnitude of these effects. Since much policy discussion has invoked replacement of AFDC by an NIT, it is interesting to see how the probability of labor force participation changes under the two different regimes. The change from AFDC to an NIT would have two effects of opposite signs. The NIT transfer payment for zero hours exceeds the AFDC guarantee by 28.7% for the average individual for the low guarantee and by 67.3% for the high guarantee plan. This effect would tend to reduce labor force participation. On the other hand, the NIT marginal tax rates are 51.6% lower for the .4 tax rate and 11.0% lower for the .6 tax rate than the .67 AFDC marginal rate. The lower tax rate will tend to decrease work disincentives. Any optimized policy would, of course, have to trade off the generosity of transfers and the cost of a program, but estimates such as ours would form the basis to evaluate the different tradeoffs.

To evaluate the disincentive effect of the different programs we chose the hypothetical mean woman in our population: 10.14 years of education, under 45 years of age, one child under six, and 4.2 family members. We then consider the probability π_j of _not_ working for different tax and transfer amounts.The probabilities are calculated for different market wage levels since these wages will affect the probabilities. The results are presented in Table 4. The first point to note is that the size of tax and transfers when coupled with a market wage do substantially affect the probability of labor force participation. The difference between the highest and lowest probability is 30.8%. Next a switch from AFDC to an NIT is likely to reduce labor force participation. Although the NIT offers lower marginal tax rates, the increased transfer amount at zero hours of work dominates in the two effects. At a $2.00 wage, a high NIT guarantee and a high tax rate, the probability of not participating rises from .729 to .864, a change of 17%. Nonetheless, it is incorrect to conclude that the effect of the NIT goes in the wrong direction. The individual is receiving a transfer payment under the NIT that is 67% higher than from AFDC, and we might well decide that the lowered labor force participation is more than offset by her increased well-being. Holding the income guarantee fixed, lowering the marginal tax rate does have an effect. For a $2.00 wage and a high NIT guarantee, lowering the marginal tax rate from .6 to .4 increases the probability of participation by 1.9% while for a $4.00 wage the effect on the probability is 3.4%. Thus, the size of the income guarantee is more important that the size of the marginal tax rate for the intervals considered in the Gary NIT experiment.[1] But both policy parameters have a significant effect on labor force participation.

This evaluation of the disincentive effects demonstrates the value of knowing explicitly the effects of transfer, taxes, and wages. The earlier sections showed that in the presence of nonconvex budget sets which arise

Table 4: Estimated Probabilities of Not Working

AFDC or NIT Plan (tax rate, guarantee %)	Wage	π_j
1. AFDC	1.50	.754
2. N=(.6, .75)	1.50	.827
3. N=(.4, .75)	1.50	.814
4. N=(.6, 1.0)	1.50	.817
5. N=(.4, 1.0)	1.50	.861
6. AFDC	2.00	.729
7. N=(.6, .75)	2.00	.818
8. N=(.4, .75)	2.00	.800
9. N=(.6, 1.0)	2.00	.864
10. N=(.4, 1.0)	2.00	.849
11. AFDC	2.50	.706
12. N=(.6, .75)	2.50	.809
13. N=(.4, .75)	2.50	.786
14. N=(.6, 1.0)	2.50	.858
15. N=(.4, 1.0	2.50	.839
16. AFDC	4.00	.640
17. N=(.6, .75)	4.00	.782
18. N=(.4, .75)	4.00	.746
19. N=(.6, 1.0)	4.00	.836
20. N=(.4, 1.0)	4.00	.808

from tax and transfer programs and the presence of fixed costs, the utility comparison method of this paper allows a structural analysis. The reservation wage theory no longer holds when taxes and fixed costs are added to a labor force participation model. Furthermore, we find the estimated size of the fixed costs to be substantial. Further research includes estimating the two stochastic factor model to determine the importance of the second disturbance term. Also, conditional on participation it would be interesting to include hours worked. However, the analysis of this paper indicates that most of the "action" may be in participation rather than in hours worked.

NOTES

Section 1

[1a] See Lewis [1956]. An early empirical study which uses the concept of the reservation wage is Gronau [1973]. Gronau mentions that taxes and fixed costs might invalidate the reservation wage model.

[1] For non-participants in the labor force it is usually not possible to observe their market wage. This problem is considered in Section 4.

[2] Many reservation wage models of labor supply do not include non-labor income which does in general affect the slope of the indifference curve at zero hours. Since y is usually correlated with variables Z, it is difficult to interpret the resulting estimates

[3] To the extent that constant hourly costs are incurred, the gross market wage is decreased by the amount of the costs. Without additional assumptions these costs could not be separated from unknown parameters of the model.

[4] Thus the first budget segment determined by net wage w_1 and virtual income y_1 - FC is an open interval on the right which does not contain zero hours. At zero hours non-labor income jumps up to y_1, because the fixed costs to working are not incurred.

[5] We will assume that other family non-labor income is zero here to simplify the presentation. However, as shown in Section 3 it can be included in the model without any complications arising.

[6] See Blinder _et al._ [1979] and Pellechio [1979] for local reservation wage models of labor force participation in the case of social security. Neither model takes into account the possibility of fixed costs of working. The Blinder methodology seems potentially extremely sensitive to the assumption of the absence of fixed costs since it does not take the different budget segments into account.

Section 2

[1] These forms of utility functions characterize the class of "self-dual" functions studied by Samuelson [1965].

[2] A closed form solution to the direct utility function is never actually needed since utility can always be evaluated using the indirect utility function with appropriate prices and non-labor income. However, considerable computational convenience arises with a closed form direct utility function.

[3] For a complete treatment of the integrability problem see Samuelson [1950] and Chipman _et al_. [1971].

[3a] Since only market demand is observed, it seems preferable to base the specification on a robust and easily estimable model of demand rather than initially choosing a utility function. Choice among demand specifications will then imply a choice of utility specifications.

[4] For a reference, see John [1978] or Courant-Hilbert [1962 , vol. 2]. Given that along the initial curve (here an indifference curve), the initial values are continuously differentiable then a unique solution to the partial differential equation exists. The technique basically justifies the use of methods of ordinary differential equations in the linear partial differential equation case.

[4a] An equivalent and perhaps insightful way to solve for u_0 is to find the wage, w*, which for a given y causes zero hours of work. It could then be used in the indirect utility function of equation (2.6). Setting h=0 and solving equ. (2.1) gives $w^* = -(\delta y + s)/\alpha$. Putting w* into the indirect utility function $v(w^*, y) = u_0 = u(0, x)$ of equation (2.10) directly. This method eliminates the requirement for an explicit closed form solution of the direct utility function since using w* in the indirect utility function gives u_0.

[5] In an instrumental variables specification of their labor supply model, Burtless-Hausman considered both sources of variation jointly, but did not find significant variation in the estimated wage elasticity which was estimated to be essentially zero.

Section 3

[1] This budget set does not take into account the effect of food stamps which are an income related program and would thus affect the budget set. For a more complete treatment of the problem see Moffitt [1977].

[2] Individuals on the experiment were not eligible for any type of child care deduction. Depending on the year of the experiment, beyond the breakeven point they might have qualified. We do not account for this possibility because its empirical significance is likely to be small.

[3] Of course, given certain values of the other parameters no $\delta^* \leq 0$ may exist to cause tangency. Then the individual will not work regardless of her value of δ. This possibility did not occur in the computational work of estimation, but it causes no special difficulty.

[4] It is interesting to note the possibility that δ^* causes u_0 to be tangent to both budget segments simultaneously. This possibility exists because y_1 exceeds $\hat{y}_1$ by the amount of the fixed costs. No problems arise from the possibility.

[5] The truncated normal density does have quite a flexible form, Johnson and Kotz [1971, vol. 2]. It can be very skew in the tail, therefore resembling an exponential distribution. The main restriction of the truncated normal density is symmetry around the mode if the mode is not on a boundary.

[6] For numerous individuals the maximum payment is not a constraint so that $H_1 = 0$. These people face a two segment budget set so that the analysis is identical to an NIT individual.

[7] Given modern techniques we could numerically integrate the resulting integrals from non-normal densities using Monte Carlo integration techniques. However, the complexity of the problem is sufficiently great that we do not pursue it here.

[8] However, a fairly simple Taylor approximation could be used to relax this assumption. We intend to try this approximation in subsequent work.

Section 4

[1] The sample is not completely random although it is not truncated as was the New Jersey NIT sample. Possible sample problems are discussed in Hausman-Wise [1979a, 1979b]. Similar results were obtained using both unweighted estimation and the weighted estimation of Hausman-Wise [1979b]. Attrition problems were not explicitly considered.

[2] See also Hanoch [1978] and Heckman [1976].

[3] A good health measure was unavailable so it could not be included. The exogeneity of health is often questionable. It is likely also to be uncorrelated with our other socioeconomic variables.

Section 5

[1] Similar results for males in the Gary NIT experiment were found by Burtless-Hausman [1978] and Hausman-Wise [1979A].

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